THE MAPPING OF BUILDABLE SLOPES IN REEDSPORT AND SUTHERLIN, OREGON: A MODEL FOR DETERMINING PERCENT SLOPE IN REQUIRED CITY-LEVEL BUILDABLE LANDS INVENTORIES

By

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List of Figures

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Introduction

Purpose

The purpose of this project is to aid the Umpqua Regional Council of Governments as they try to identify buildable lands in Douglas County, Oregon particularly in the cities of Reedsport and Sutherlin. This project will help Reedsport upgrade its recently completed Buildable Lands Inventory and provide Sutherlin with a method to more accurately determine its buildable land for its next periodic review. In doing so, this project will provide a feasible method for Oregon communities to address slope hazard and development, as they build a rationally based land use plan.

Project Objectives

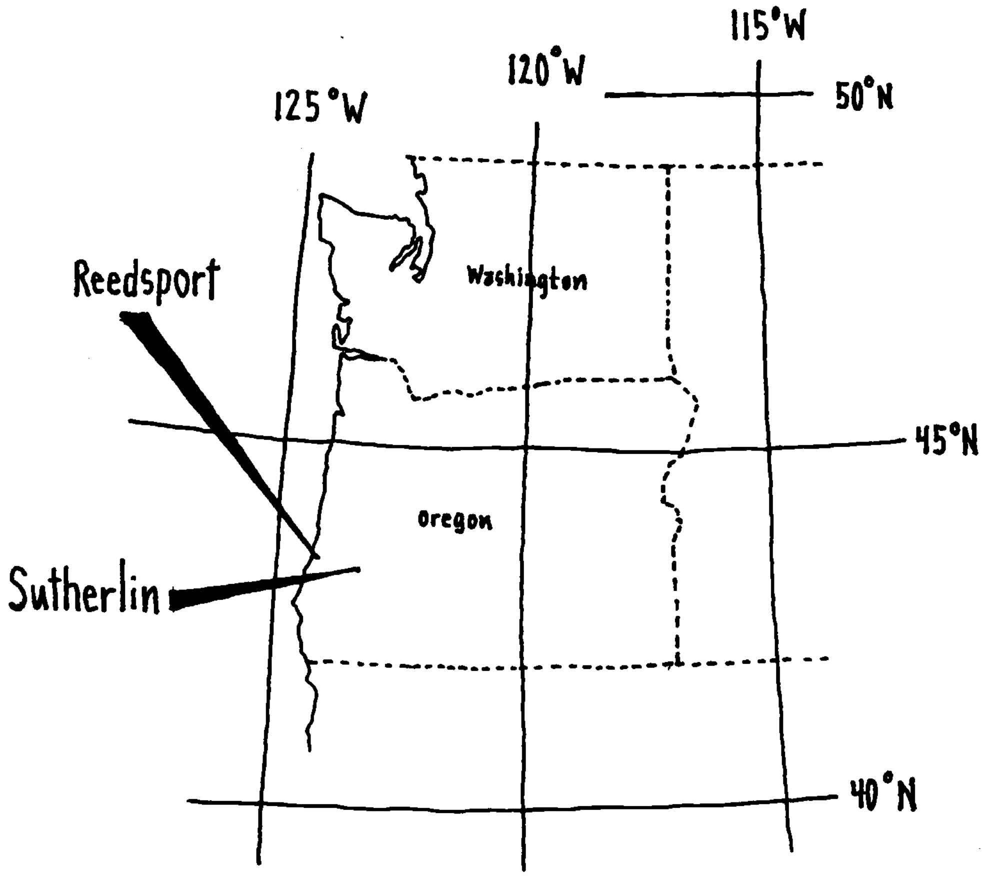
The scope of the project is to identify buildable slopes (slopes less than 25 percent) at these two study areas. To do so the project will meet several objectives:

1. determine the usefulness of existing slope data sources for the purpose of defining buildable slope,
2. establish a methodology for accurately defining buildable slope,
3. provide slope maps which identify buildable and unbuildable slopes and can be used in a Geographic Information System (GIS) to help determine buildable lands,
4. discuss the limitations of the maps.

Study Areas

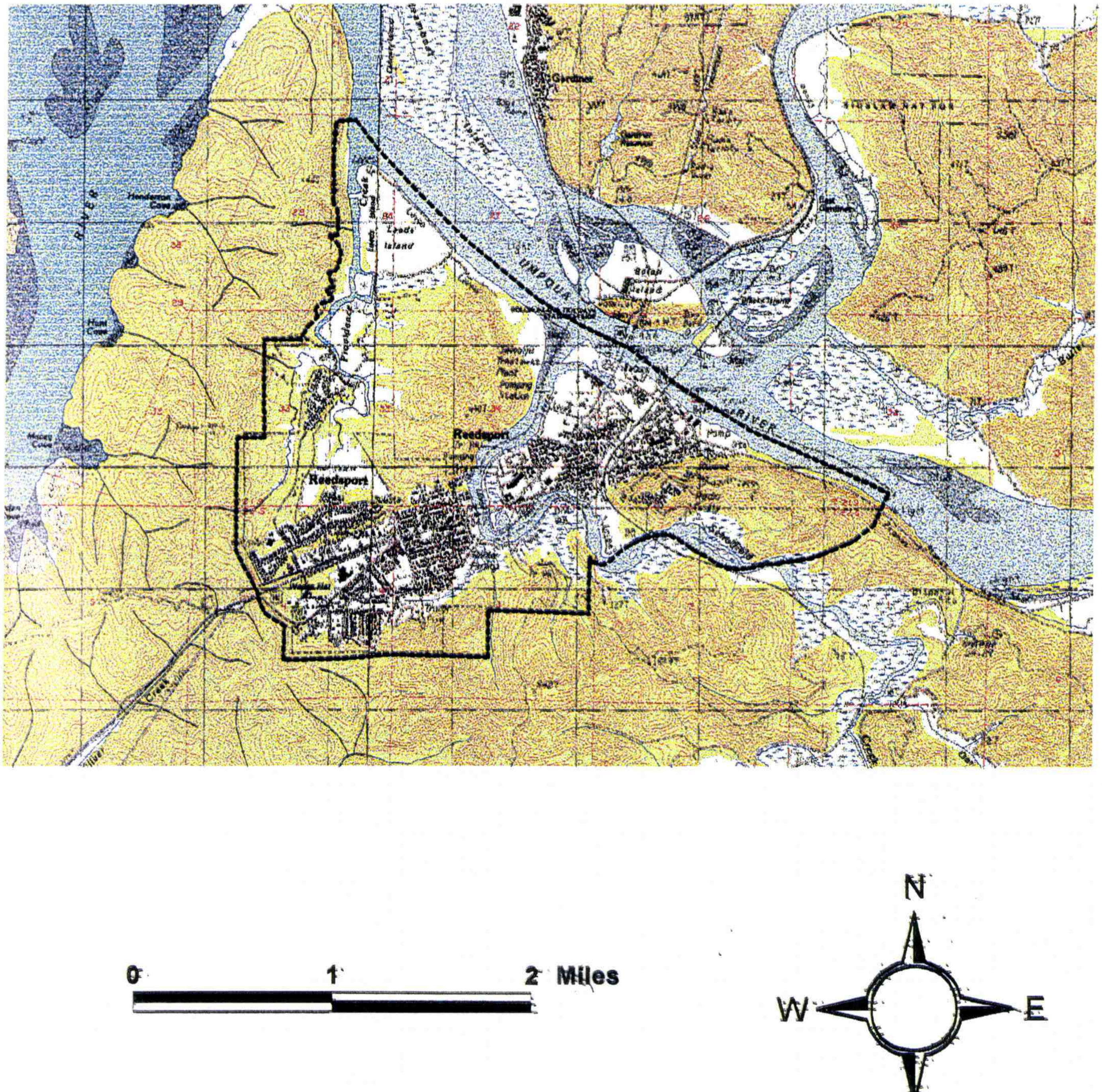
This study took place in two cities in Douglas County, Oregon, Reedsport and Sutherlin (Map 1). Reedsport (Map 2) is a coastal community located at approximately 43 1/2 degrees north latitude, 124 degrees west longitude, near the mouth of the Umpqua River, along the boundary of the Coast Range and the Oregon Sand Dunes which run along a portion of the south central coast. Sutherlin (Map 3) is located some 60 miles east and 25 miles south of Reedsport. It lies inland, along Interstate 5, and is considered a bedroom community to the larger city of Roseburg 10 miles south. Both communities are surrounded by foothills of moderate slope.

Relative Location of Study Areas



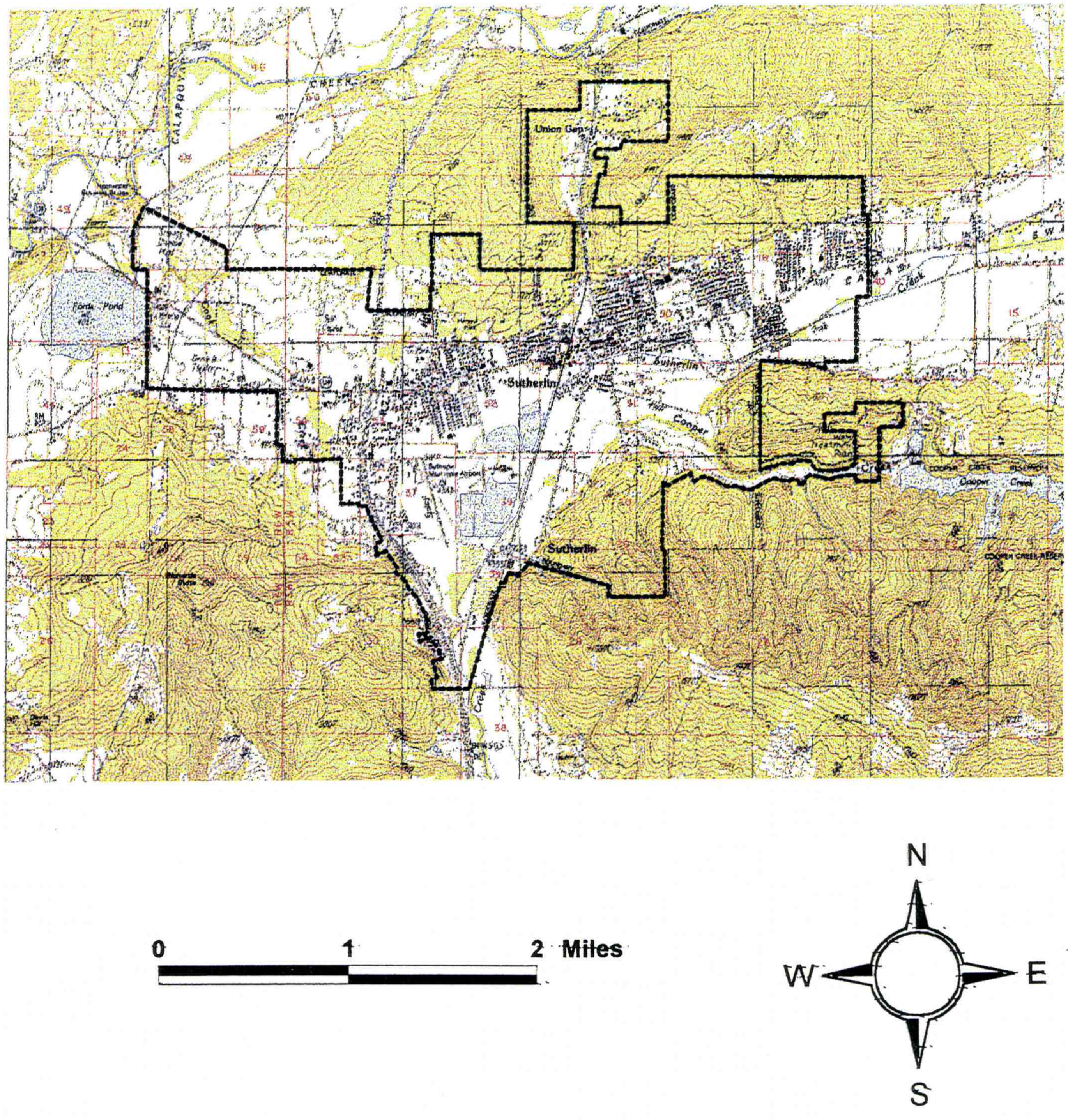
Map 1 (taken from Goode's 1995 World Atlas p. 96).

City of Reedsport



Map 2 (taken from Reedsport 7.5 minute USGS Topo Sheet).

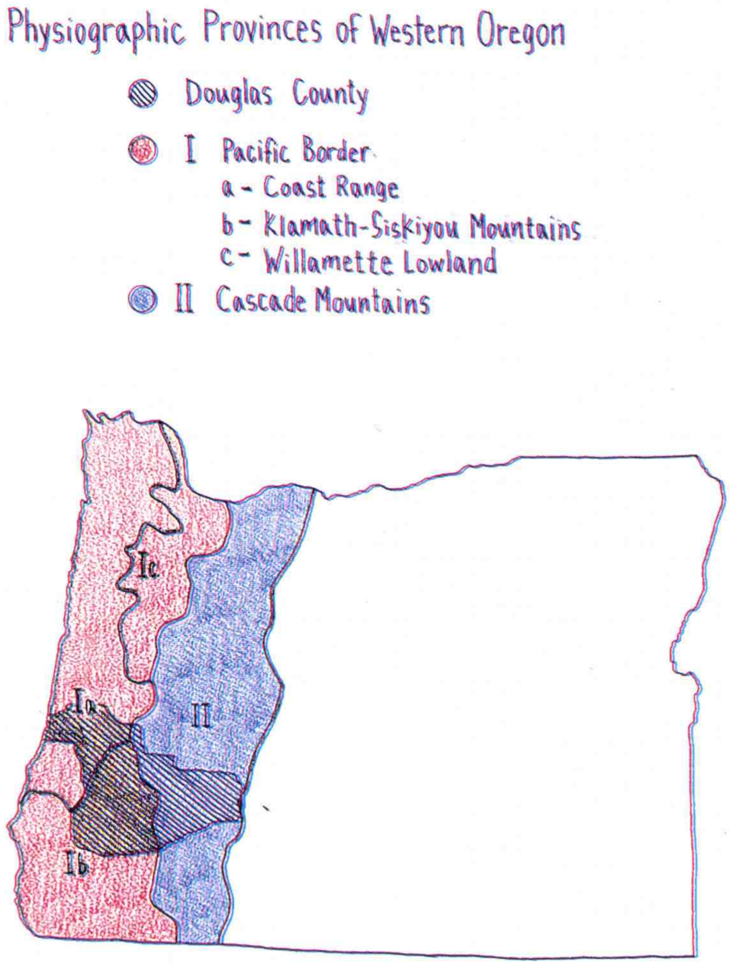
City of Sutherlin



Map 3 (taken from Sutherlin 7.5 minute USGS Topo Sheet).

Physiography of Douglas County in Western Oregon

Western Oregon is comprised of two physiographic provinces-The Cascade Mountains and The Pacific Border, which is subdivided into three terranes-the Coast Range, the Willamette Lowland, and the Klamath-Siskiyou Mountains. Douglas County consists of land within the Cascade Province and the Coast Range and Klamath-Siskiyou Mountain Terranes (See Map 4).



Map 4 (taken from the Atlas of the Pacific Northwest).

The Cascade Mountains landform is "composed of (1) underlying layers of early Tertiary tuffs, breccias, lavas, and mudflows, exposed in the Columbia River Gorge and other deep valleys; (2) a thick middle section of Tertiary basalts that form the deeply eroded Western Cascades; and (3) an upper section of Tertiary and Quaternary andesites and basalts that form the less dissected High Cascades lava platform"(Jackson and Kimerling 1993). This region is also characterized as two longitudinal halves-the Western Cascades which range in elevation between 1,700 and 5,600 feet and the High Cascades to the east which exceed 11,000 feet.

The Coast Range is made up of moderately folded sandstones and shales with basalts and igneous intrusions. The crest of the range averages 1500 feet with a maximum elevation of 4,097 feet (Orr et al. 1992).

The Klamath-Siskiyou region is the oldest region in western Oregon and has a confused geologic record masked by metamorphic recrystallization. This region is characterized by many deep, narrow canyons and peaks over 7000 feet.

Western Oregon receives most of its precipitation during winter and has prevailing winds from the west and south during this season. Slopes facing this direction are subject to the greatest erosional forces. The effects of orographic precipitation cause great variability in rainfall amounts from one side of each province to the other. It is not uncommon for the western slopes to have more than twice as much precipitation as their eastern counterparts. The lowland regions between the mountainous parts of the three provinces have annual precipitation rates of 35-45 inches. The Coastal region receives an average of 60-80 inches annually, while the Cascade region receives an average of 70 to over 100 inches (Jackson and Kimerling 1993).

Western Oregon is heavily forested. The Coast Range, Western Cascades, and Klamath-Siskiyou Mountain Regions contain most of Oregon's forest lands. The region's west coast, mid-latitude position, geologic history, mild, moisture-rich climate, and relatively productive soils account for the abundance of vegetation which, in areas considered to have unstable slopes, is primarily timber (Burroughs 1983). These steep, timber-rich, mountain regions, which cover most of Western Oregon are susceptible to natural hazards, mainly landslides, especially when altered by human activity such as timber harvest, road construction, and development (Swanson and Dyrness 1975, Sidle et al. 1985).

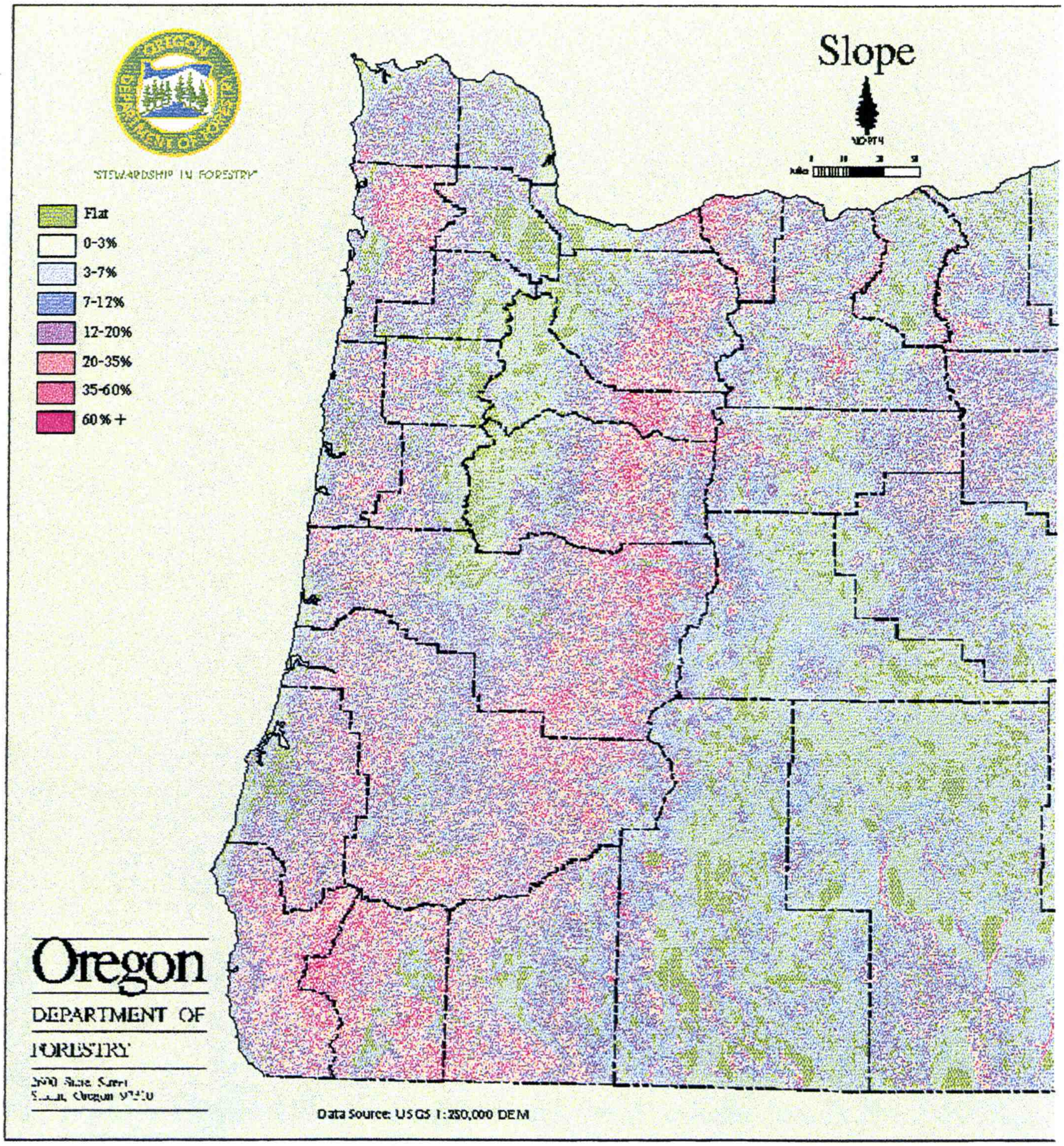
Western Oregon's timber-rich regions, however, are not the only areas susceptible to slope failure. Many areas of the Willamette lowland and similar landscapes are prone to slope related hazards. In the Portland area alone over 700 landslides, varying in size, were the result of the the same storms which caused the major flooding in 1996. According to Scott F. Burns, on the geology faculty at Portland State University who studied most of the slides in the Portland Area, human activity increased the risk of these slides in 76% of the cases (Hill 1998). He also stated that 52% of the slides occurred on slopes cut for driveways and roads.

Slope Data

Though percent slope is only one of many factors attributing to slope failure it is one of the easiest to measure. Other factors which attribute to slope failure, such as rock structural strength, soil characteristics, vegetative cover strength, and saturation levels, are difficult to measure and much more complex to estimate than percent slope.

The existence of relatively accurate contour maps and digital elevation models allow people to measure percent slope fairly accurately at varying scales. Map 5 shows percent

Percent Slope Values of Western Oregon



Map 5 (taken from Oregon Department of Forestry Website).

slope at the 1:250,000 scale to illustrate general patterns of slope at the state level. Widely available 30 meter resolution digital elevation models, taken from 7.5 Minute U.S.Geologic Survey Topographic Quads, provide county level percent slope data. Even finer still, there are 10 meter resolution digital elevation models and high resolution photogrammetric mapping data sources. Field survey methods and global positioning systems provide slope data at the finest scales.

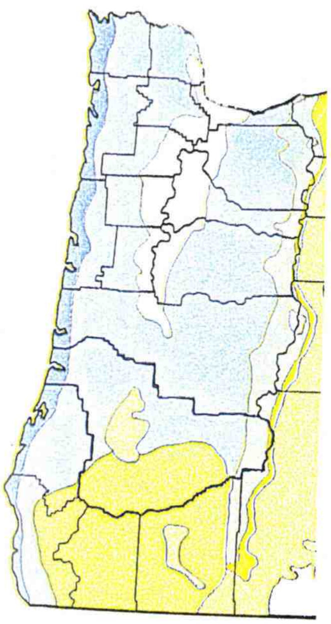
Identifying slope is very important in Douglas County. Douglas County is arguably the most diverse county in Oregon when it comes to landscape patterns. According to the Atlas of the Pacific Northwest, Douglas County has more defined vegetation zones, ecoregions, soils sub-orders, and landform terranes than any other county in Oregon (See maps 6,7,8). During the heavy rains of 1996, Douglas County was one of the two hardest hit counties in the state, sustaining extensive landslide damage (Rosenfeld 1998). Many cities in Douglas County are experiencing growth rates higher than the state average; this growth increases the need for housing and service base development (Hinman 1999). These factors demonstrate the need for proper land use planning.

Oregon's Planning Goals

Oregon's Department of Land Conservation and Development has adopted 19 statewide planning goals in its Land Use Program (See Appendix A). These goals are meant to guide cities and counties as they construct comprehensive plans and ordinances. It is expected that cities, counties, and federal and state agencies will adhere to these guidelines. Three most important issues are Land Use Planning, Citizen Involvement, and maintaining Oregon's Agricultural and Forest Lands (Oregon DLCD 1999).

Regional Vegetation, Ecoregion, and Soils Landscape Patterns

VEGETATION ZONES



Forest Province

Sitka Spruce Zone. Confined to the coast, this coniferous zone extends from Alaska to southwestern Oregon and has been extensively altered by logging and fire. Sitka spruce (*Picea sitchensis*) characterizes the zone although in many places western hemlock (*Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziesii*) dominate. Red alder (*Alnus rubra*) often forms patches in disturbed areas and riparian situations, while western redcedar (*Thuja plicata*) characterizes swampy habitats. Besides stabilized dune communities in which shore pine (*Pinus contorta*) is a prominent successional species, there are salt marsh communities in estuaries and communities associated with shifting dunes. The Sitka Spruce Zone grades into the Western Hemlock Zone to which it is closely related.

Western Hemlock Zone, mantling both the Coast Range and western slopes of the Cascades, this zone is one of the most extensive in the region, stretching from British Columbia to California. Although named for the shade-tolerant western hemlock characterizing the persistent vegetation, the dominant tree is often the seral Douglas-fir. Extensive logging has occurred throughout the area. Communities within this zone have been studied in detail and have been related to site characteristics. Some important species are western redcedar in moist sites and, in the south, ponderosa pine (*Pinus ponderosa*) and incense cedar (*Calocedrus decurrens*). In disturbed moist sites, red alder and bigleaf maple (Acer *macrophyllum*) are common. Western hemlock gives way to Douglas-fir in drier sites and Pacific silver fir (*Abies amabilis*) at higher elevations.

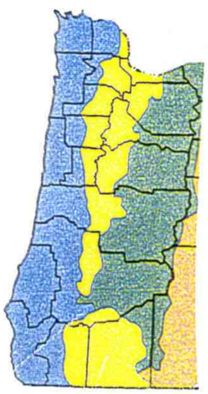
Cascade Subalpine Forest Zone Complex. A group of zones marked by heavy snow flanks the Cascades and Olympics and extends into British Columbia. This group includes the Pacific Silver Fir Zone marked by *Abies amabilis.* At higher elevations, silver fir gives way to a more stunted forest of mountain hemlock (*Tsuga mertensiana*) and subalpine fir (*Abies lasiocarpa*) and forms a parklike pattern of open meadow and forest stringers. In areas of volcanic ash or areas recently disturbed by fire, even-aged stands of lodgepole pine (*Pinus contorta* var. *murrayana*) prevail. In southern Oregon, the zones bear close relationship to the California red fir forest.

Mixed Needleleaf-Broadleaf Forest Zone Complex. A highly intricate set of zones closely related to plant communities in California, this mixed evergreen forest straddles the Siskiyou Mountains in southwestern Oregon. Edaphic, fire history, and climatic contrasts lead to sharp breaks in plant cover. Douglas-fir dominates the upper canopy, but various sclerophyllous trees and shrubs are found in the understory including tanoak (*Lithocarpus densiflorus*), canyon live oak (*Quercus chrysolepis*), Pacific madrone (*Arbutus menziesii*), and golden chinquapin (*Castanopsis chrysophylla*). Serpentine soil bears a distinctive flora and sparse vegetation, and other dry rocky areas support sclerophyllous broadleaf chaparral.

Rogue-Umpqua Forest-Shrub Zone Complex. Occupying valleys in the rainshadow of the Siskiyou Mountains is a vegetation mosaic exhibiting many xeric characteristics. Woodlands are dominated by Oregon white oak (*Quercus garryana*), with California black oak (*Q. kelloggii*) on mesic sites. Pacific madrone, ponderosa pine, sugar pine (*Pinus lambertiana*), and incense cedar distinguish this zone from Willamette Valley forest. On shallow soils, south slopes, and recently burned areas, sclerophyllous shrub communities are found with narrow-leaved buckbrush (*Ceanothus cuneatus*) and white-leaved manzanita (*Arctostaphylos viscida*).

Grand Fir and Douglas-fir Zones. Mesic coniferous forests occur in interior areas and exhibit a broad distribution. Often both grand fir (*Abies grandis*) and Douglas-fir occur in mixed stands, although Douglas-fir tends to be more prevalent in Idaho. Other trees of importance, in order of increasing moisture tolerance, are ponderosa pine, western larch (*Laris occidentalis*), and lodgepole pine; the latter two species are fire-responsive pioneers. In northern Idaho, western redcedar and western hemlock are prominent. Oregon boxwood (*Pachystima myrsinites*) and common snowberry (*Symphoricarpos albus*) dominate two prevalent understory communities.

ECOREGIONS



Coast Range

Puget Lowland

Willamette Valley

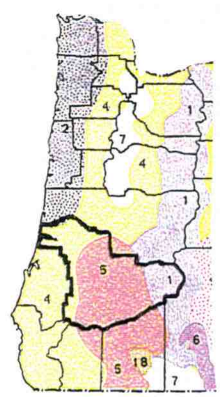
Cascades

Sierra Nevada

Eastern Cascades Slopes And Foothills

Columbia Basin

SOIL ORDERS AND SUB-ORDERS



Inceptisols

1 *Cryumbrepts*—in cold regions.

2 *Haplumbrepts*—in temperate to warm regions.

Andepts are soils with high contents of volcanic ash and ar[e] therefore of low bulk density. They are of recent development, occurring in mountainous areas in Idaho and in the North Cascades under cool summer conditions.

3 *Cryandepts*—in cold regions.

Ultisols

4 *Haplohumults*—with subsurface horizon of clay and/or weatherable minerals; in temperate climates.

Xerults are freely drained Ultisols in areas of Mediterranean climate with little organic material in the upper horizons and are seldom saturated with water. They are confined to the hilly regions in the middle portions of the Rogue and Umpqua drainages and support a mixed coniferous-broad-leaved evergreen vegetation with xeric elements.

5 *Haploxerults*—with a surface clay-rich horizon either having weatherable minerals or a decreasing clay content with depth, or both.

Maps 6-8 (Taken from the Atlas of the Pacific Northwest).

This project was developed in response to three of these statewide goals: Goal 2 (Land Use Planning), Goal 7 (Areas Subject to Natural Disasters and Hazards), and Goal 10 (Housing).

Goal 2 states that "land-use decisions are to be made in accordance with a comprehensive plan, and that suitable 'implementation ordinances' to put the plan's policies into effect must be adopted", and, "It requires that plans be based on 'factual information'." Goal 2 also states that, "All land use plans shall include identification of issues and problems, inventories and other factual information for each applicable statewide planning goal" (Oregon Revised Statutes 1999).

Goal 7 aims to protect life and property from hazards and disasters. This goal states that"Developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without proper safeguards". When planning for Goal 7, "Areas subject to natural hazards should be evaluated to the degree of hazard present" (Oregon Revised Statutes 1999).

Goal 10 aims to meet the future housing needs of the state. This goal states that, "buildable lands for residential use shall be inventoried and plans shall encourage the availability of adequate numbers of needed housing units." Goal 10 defines buildable lands as "lands in urban and urbanizable areas that are suitable, available and necessary for residential use." This goal also states that "plans should be developed in a manner that insures the provision of appropriate types and amounts of land within urban growth boundaries" (Oregon Revised Statutes 1999).

Legislation

Each city in Oregon is required to identify an urban growth boundary (UGB) in its comprehensive plan for land use. Oregon Revised Statute (ORS) 197.296, under Urban

Growth Areas, requires this boundary to include current city lands and sufficient other land, buildable land, to meet expected growth requirements. Oregon Administrative Rule(ORA) 660-008-0005 further states that " ' Buildable Land' means residentially designated vacant and, at the option of the local jurisdiction, redevelopable land within the urban growth boundary that is not severely constrained by natural hazards." This rule also states that, for density calculation purposes, land with slopes of 25 percent or greater is generally considered unbuildable unless otherwise provided for at the time of acknowledgment (Oregon Administrative Rules 1999).

House Bill 2709, adopted in 1995, states that during the periodic review phase of the comprehensive planning process, plans should include sufficient buildable lands within the UGB to meet the estimated housing needs for 20 years (House Bill 2709 1999).

House Bill 2709 also identifies those cities in Oregon which are subject to ORS 197.296 (See Appendix B). Cities are subject to this statute if they:

1. Have a population greater than 25,000.
2. Have a growth rate that exceeds the average growth rate for the state.
3. Are in the Portland Metro Area.

Roseburg, Sutherlin, and Canyonville in Douglas County are all subject to ORS 197.296 for higher than average growth rates. Reedsport is subject to this statute because it is in its process of periodic review. Growth rates are based on the previous five year's state growth rates calculated by The Center for Population Research and Census at Portland State University (Hinman 1999).

Methods

The data used were chosen because they were readily available at reasonable cost, because 30 meter resolution DEMs are too coarse for local level analysis (See Map 9 which begins to get fuzzy as it approaches the city level), and because 10 meter resolution DEMs and higher resolution contour data are not yet available for this region of Oregon.

To meet project objectives 1, 2, and 3 the following steps were taken:

<u>Step 1</u>

Using ArcView GIS, the Umpqua Regional Council of Government's (UR-COG) GIS staff began the process of identifying percent slope (See Maps 10 and 11) by examing existing soils layers taken from 1:24000 1998 Digital SURRGO Soils Data for Reedsport and Sutherlin.UR-COG classified soils polygons in the areas within and adjacent to the urban growth boundary according to the range of slopes present in each polygon. Four classes were identified: under 12 percent, 12-25 percent, 25 percent or greater, and "needs checking". These classifications were arbitrarily chosen to distinguish low buildable, moderate buildable, and steep unbuildable slopes. The "needs checking" category consisted of soils polygons which had slope values both greater than and less than the 25 percent cut off value.

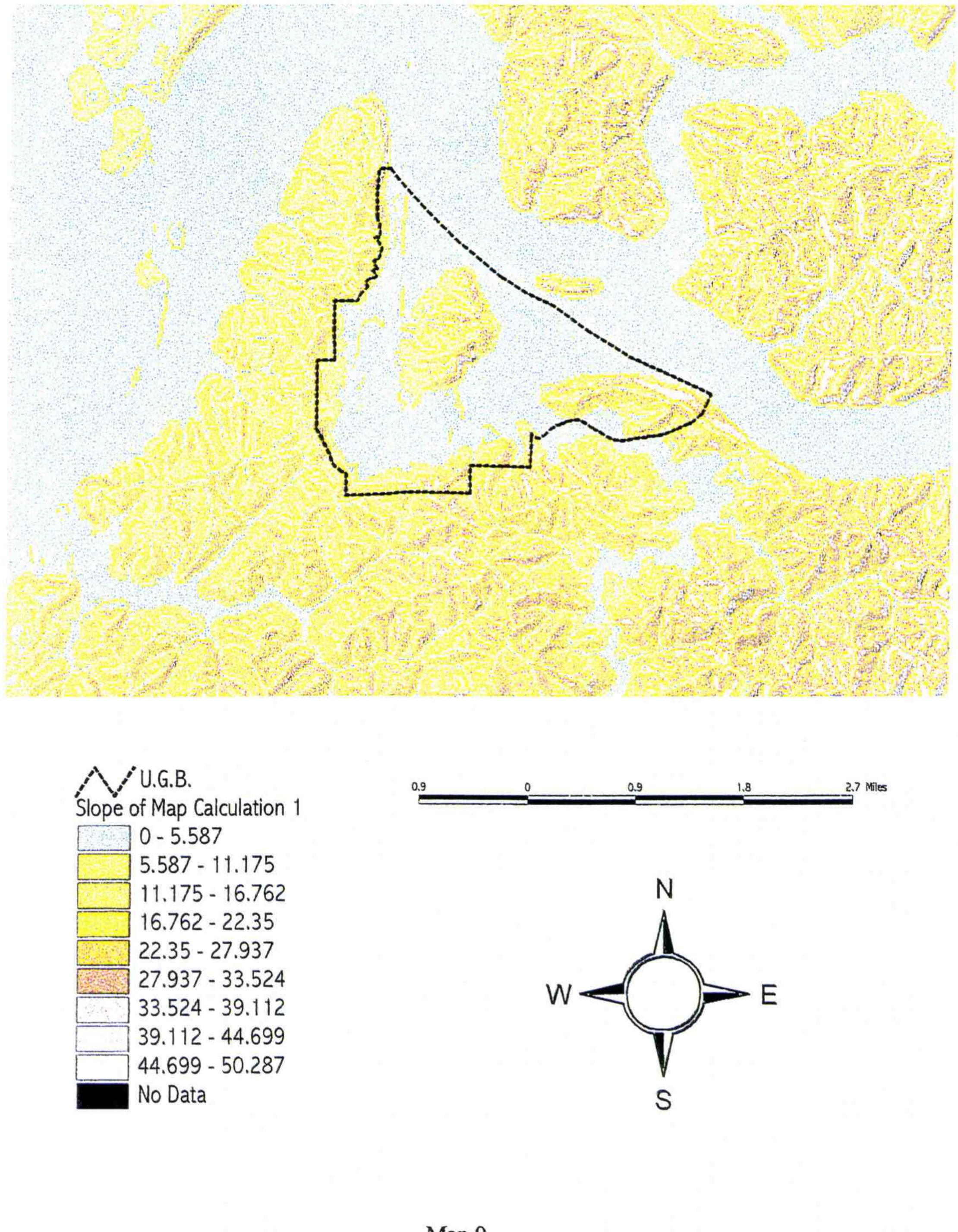
<u>Step 2</u>

To clarify the ambiguity in the soils data, USGS 7.5 topographic quads were used to better identify slopes within the "needs checking" class and to validate the other classes. Percent slope was determined from the topo maps using the trigonometric function:

$$S = (a/b) \times 100$$

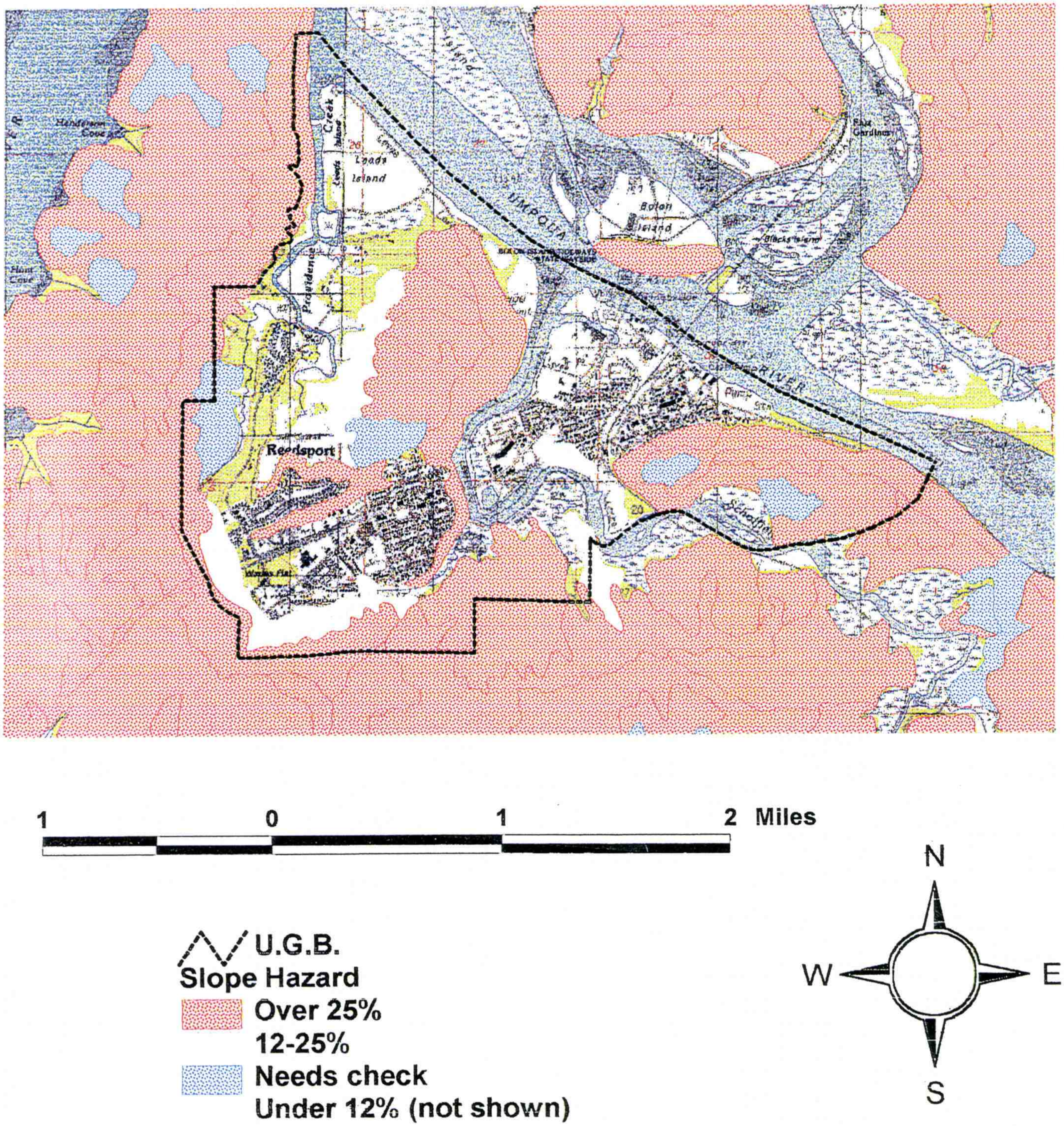
where S = percent slope, a = change in elevation (rise), and b = distance (run).

Percent Slope for Reedsport Area from 30-meter Digital Elevation Model



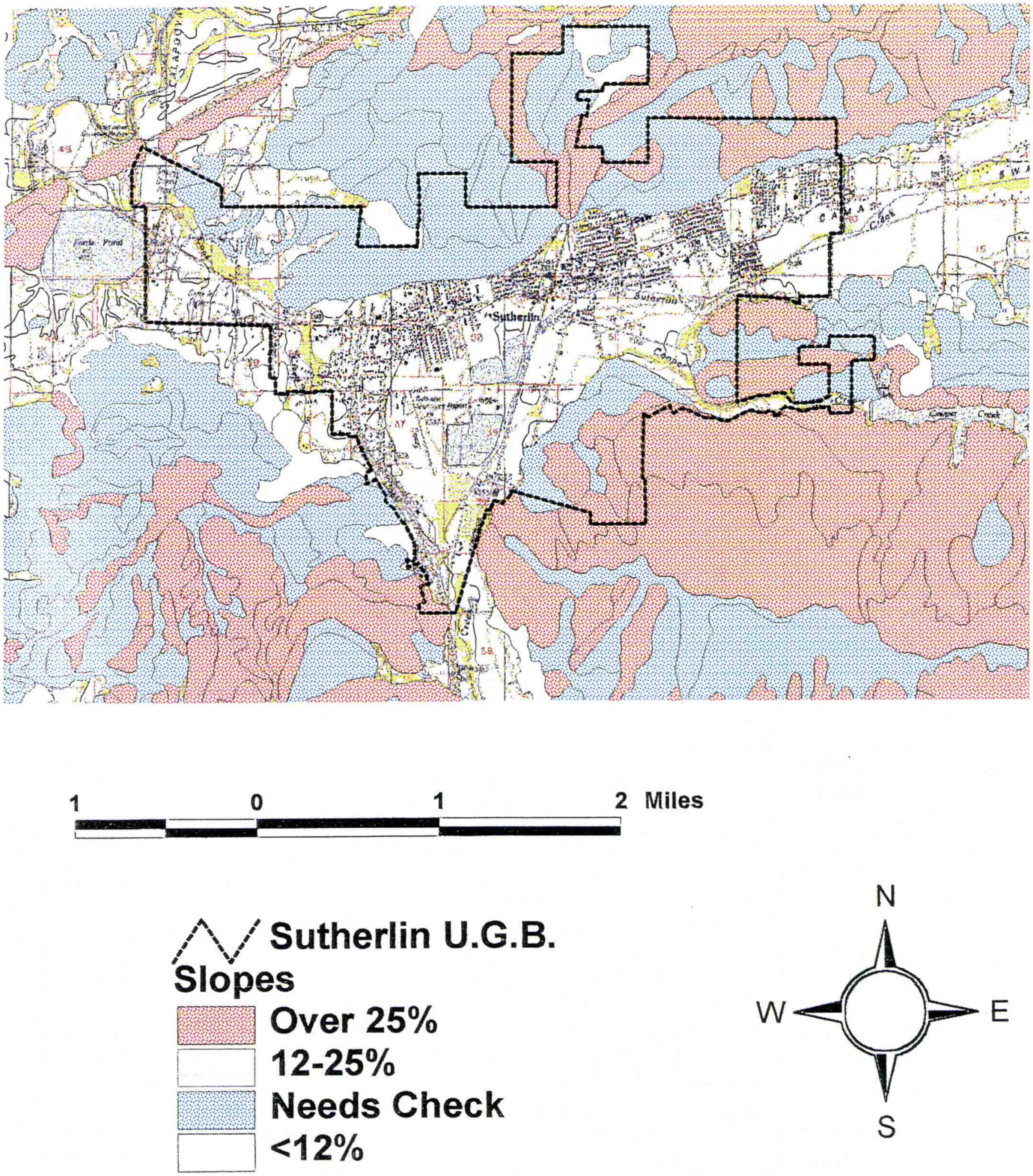
Map 9.

Initial Classification of Reedsport Soils Data



Map 10 (taken from Digital SURRGO soils data).

Initial Classification of Sutherlin Soils Data



Map 11 (taken from 1998 Digital SURRGO soils data).

The rise of topographic contours is consistent. For the 7.5 minute 1:24000 scale topo maps used, the contour interval is 40 feet. Using common, engineer's scale, fractional measurements and the given map scale (1:24000 or 1 inch represents 2000 feet), slope percents were determined for a set of contour interval spacings (See Table 1).

Table 1. Contour interval spacings on 7.5 minute (1:24000) topographic maps corresponding to various slope percents.

Distance on map in inches	Distance on ground in feet	Percent Slope
1/2	1000	4
1/4	500	8
1/6	333.33	12
1/8	250	16
1/10	200	20
1/12	166.67	24
1/16	125	32

Upon establishing 1/12 inch as the best estimator of 25 percent slope, the 60 unit function on an engineer's scale was used to measure all contour gaps, in each of the polygons that needed checking, which appeared larger or smaller than that measure, with the purpose of identifying how the polygons should be reclassified. The following conditions for classification were applied:

1. If all measurements within a polygon were below 25 percent (1/12 inch or greater), it was deemed buildable slope.
2. If all measurements within a polygon were 25 percent or above (less than 1/12 inch), it was deemed unbuildable.

3. If both above and below it was deemed to still need checking.

Step 3

A percent slope map was created for the Reedsport study area. Essentially, this map is a percent slope contour map of the Reedsport 7.5 minute topo maps. Using the contour gap identified in Step 2 (1/12 inch) and by establishing the location where each set of two contours lined up with the lines identifying 1/12 inch on an engineer's scale, marking the mid-point between those contours, and connecting the adjacent dots, a smoothed approximation of 25 percent slope was delineated. The percent slope contours manually delineated on the 7.5 minute topo maps, from the contour analysis, were carefully traced onto mylar and scanned to create a digital image (JPEG). The contours were transferred to mylar to eliminate all other data which would have been captured in the scanning process. The scanned image was then entered into Arcview GIS, converted to a grid, and geometrically rectified, to fit the image to real-world positional coordinates and establish topology.

Step 4

Step 4 involves a visual comparison of the Reedsport percent slope map from the soils reclassification and the Reedsport percent slope map created from the contour analysis. To effectively make such a comparison a map was created in Arcview 3.1 by overlaying the soils reclassification data on top of the contour analysis data.

Step 5

Step 5 involved field surveying with a Trimble Pro XR Global Positioning System (GPS), to determine percent slope at selected field locations. At each point, data were collected on elevation in meters and global position in UTM meters. Each site that needed checking was surveyed, provided the four following conditions were met:

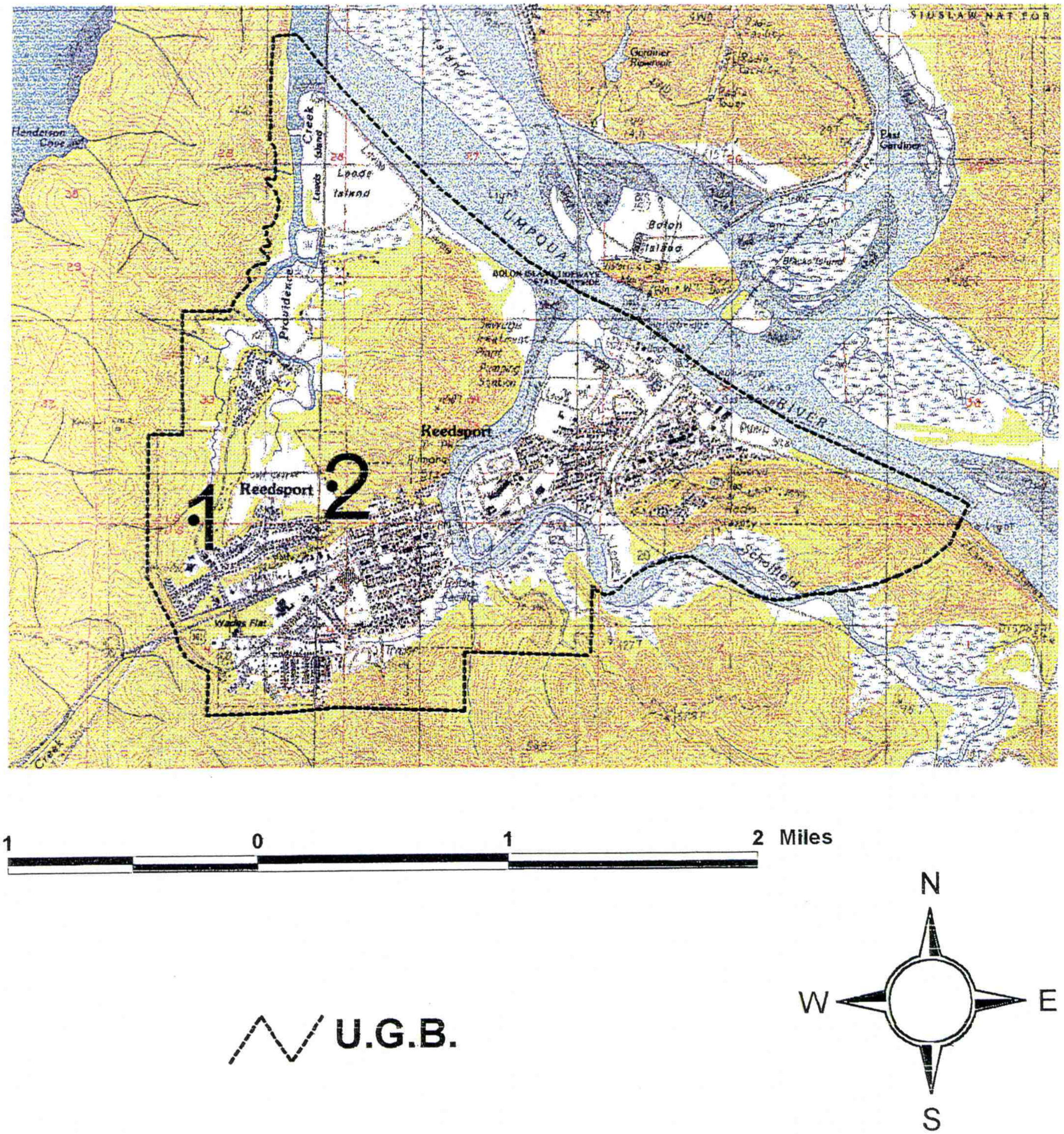
1. Permission could be gained from the land owners of any land with no trespassing signs.
2. There was adequate open space trending perpendicular to the slope to obtain accurate GPS data, i.e. trails, roads, and fields.
3. Road access was available to some part of the polygon
4. The City Manager identified that area as having a potential for city services, i.e. sewer and water.

During the field survey, six sites were established for GPS data collection. Two sites were located in Reedsport and four in Sutherlin (See Maps 12a and 12b). These sites were chosen because they were the only areas which met the stated requirements. Within these six study sites, 20 GPS points were utilized for analysis. GPS points were discarded if the standard deviation was greater than 1 and/or the transect between any two given points was not relatively perpendicular to the contour lines.

The GPS point data were real-time differentially corrected, a process which provides more accurate positional results by comparing the field data to data from a known position, entered into Arcview 3.1 Desktop GIS, and then checked for error. Using the measurement tool in Arcview, the distance between GPS points was determined. These data were used to calculate slope percents for comparison to those obtained in Steps 2 and 3. Also, during the field survey a visual survey for slope hazards was conducted. Each survey point included the following visually checked features:

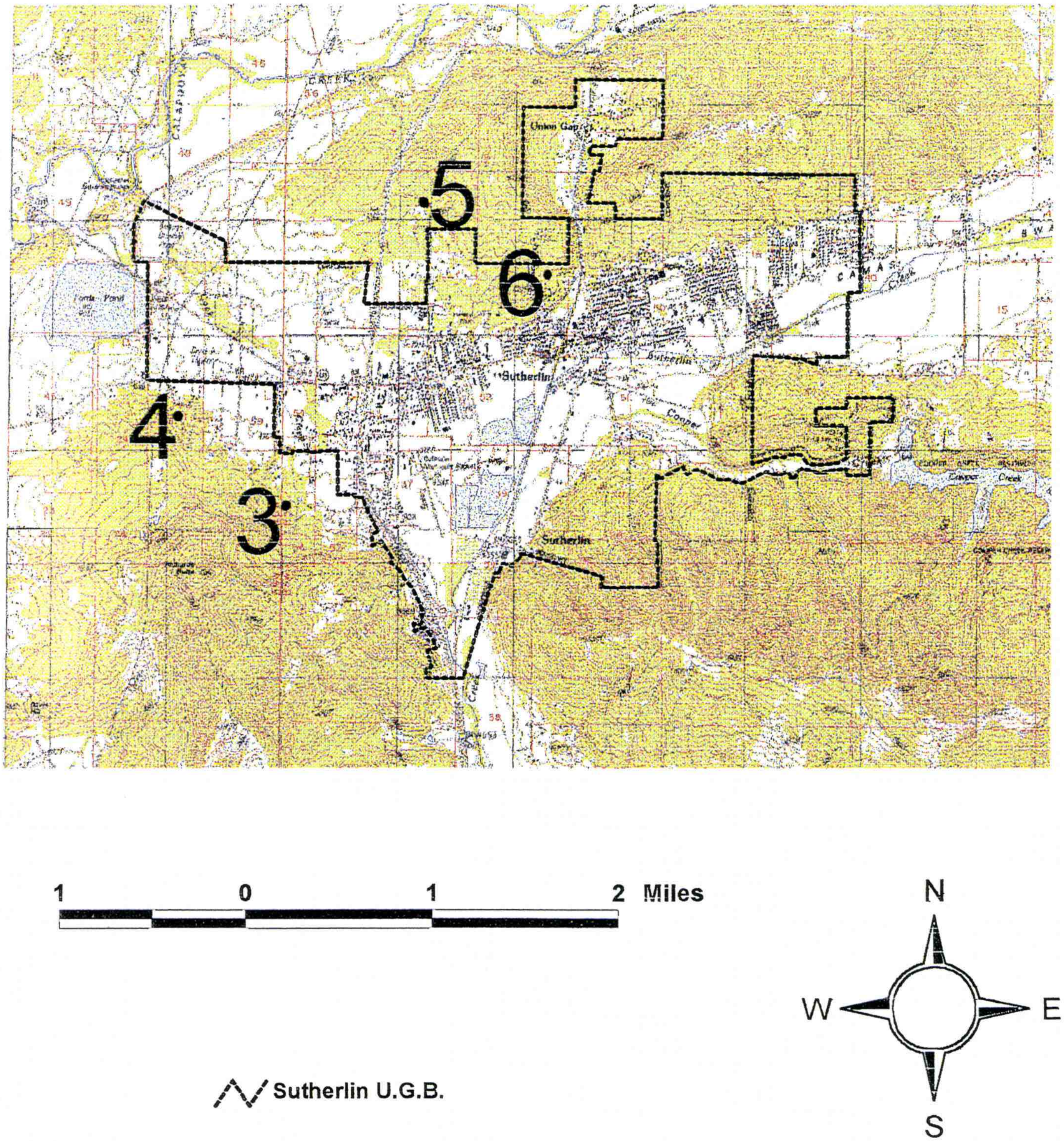
1. Presence of obvious, current or previous slope failure.
2. The presence of biological indicators of slope movement such as fallen, tilted, or J-shaped trees and vegetation cover in an early successional phase.

Reedsport Study Sites



Map 12a.

Sutherlin Study Sites



Map 12b.

Results

Reclassification of Soils Polygons

Reclassifying the soils polygons which needed checking turned out to be quite an easy task. None of the "needs checking" polygons in either Reedsport or Sutherlin experienced any changes based on the criteria listed in Step #1. Every polygon which needed checking after the initial soils data classification had contour gaps both less than and greater than 1/12 inch or 25 percent slope. Therefore, these polygons were considered to still need checking.

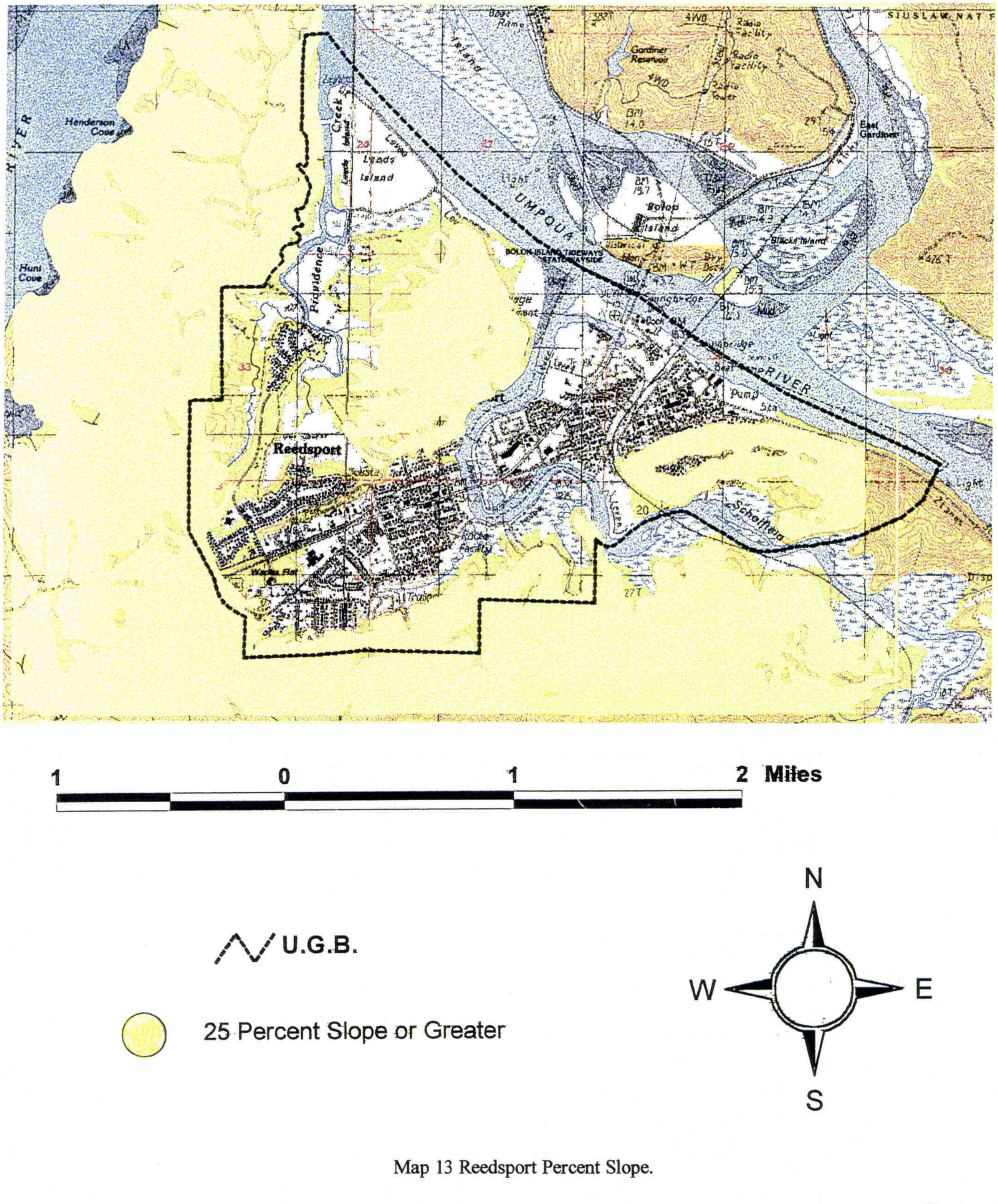
Alternative Slope Determination

Since the reclassification of the soils polygons could not clarify the percent slope status within those polygons which needed checking, an alternative analysis was performed on one of the two study areas. Map 13 is the result of this alternative analysis. This map shows percent slope overlain on the Reedsport 7.5 minute topo maps . The contour analysis used to delineate the extent of slopes greater than or equal to 25 percent in Reedsport provides a clear appropriately scaled map of this spatial phenomenon.

Comparison of Percent Slope Maps

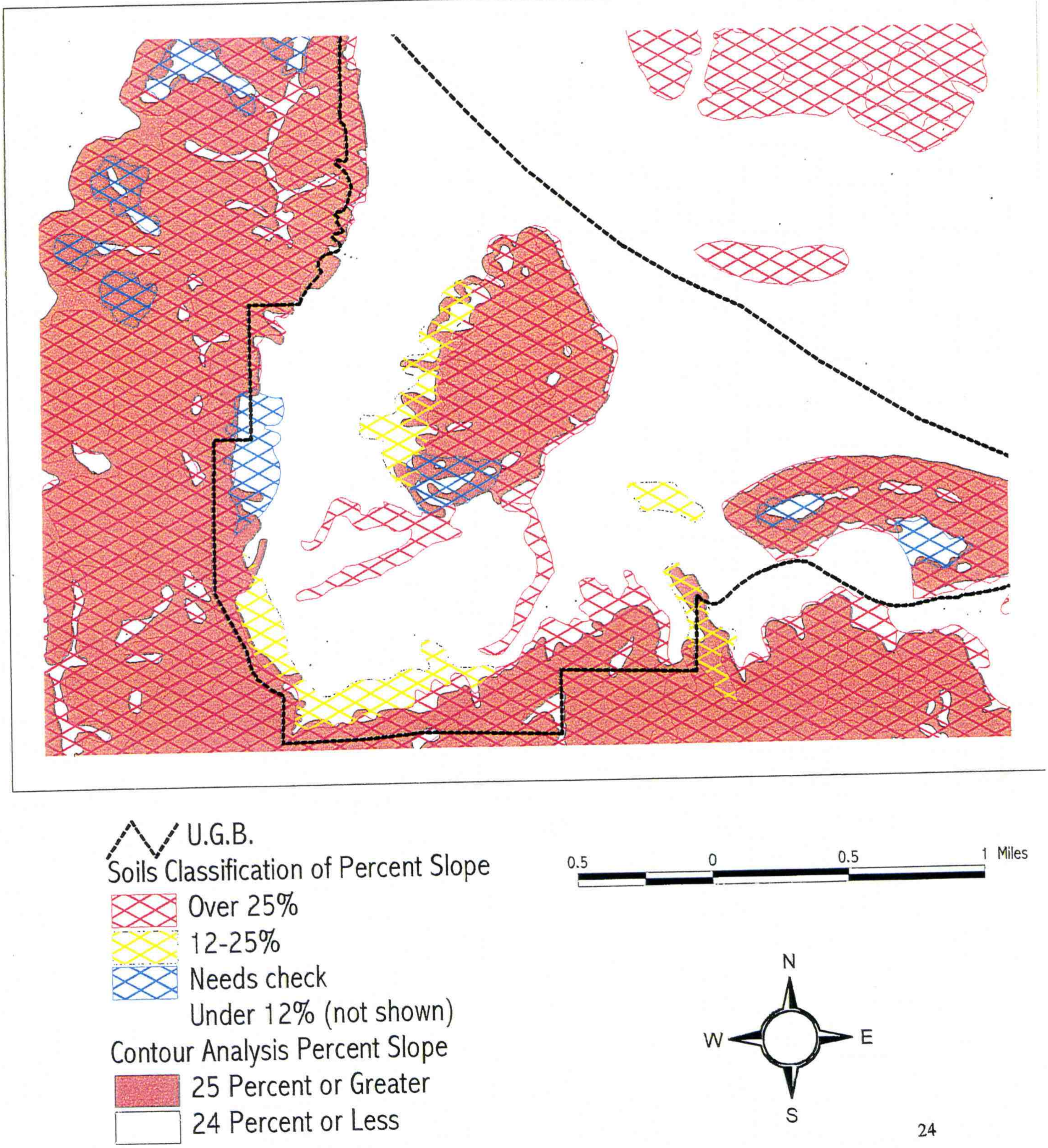
Map 14 illustrates the spatial variation between the delineation of 25 percent slope from the soils data and from the contour analysis. The contour analysis results contradict each percent class of soils slope polygon. Two of the polygons classified as 12-25 percent had significant areas of slope classified as 25 percent or steeper in the contour analysis. Within the urban growth boundary several areas were classified as 25 percent or greater but were not detected as such in the contour analysis.

Percent Slope for Reedsport Area from 7.5 minute USGS contour analysis



Map 13 Reedsport Percent Slope.

Percent Slope
A Comparison between Soils Classification and Contour Analysis



Map 14 Reedsport Percent Slope Comparison.

Statistical Results of GPS Data

The point data collected during the GPS survey and utililized during the GPS slope analysis are statistically accurate. The range of standard deviation in accuracy was from .252 to .467. The range of vertical precision was from 3.5 to 5.4 meters, while the range in horizontal precision was from 2.3 to 3.2 meters. While the standard deviations of each point are within the acceptable range, the precision values which could be plus or minus several meters, suggest that error capable of affecting the results could exist.

GPS Slope Survey Results

The determination of percent slope and slope hazard from the GPS survey provided a wide range of values, with each study site providing insight to the process. Percent slope was calculated between each utilized point (section) and and the maximum transect (total length) for each site.

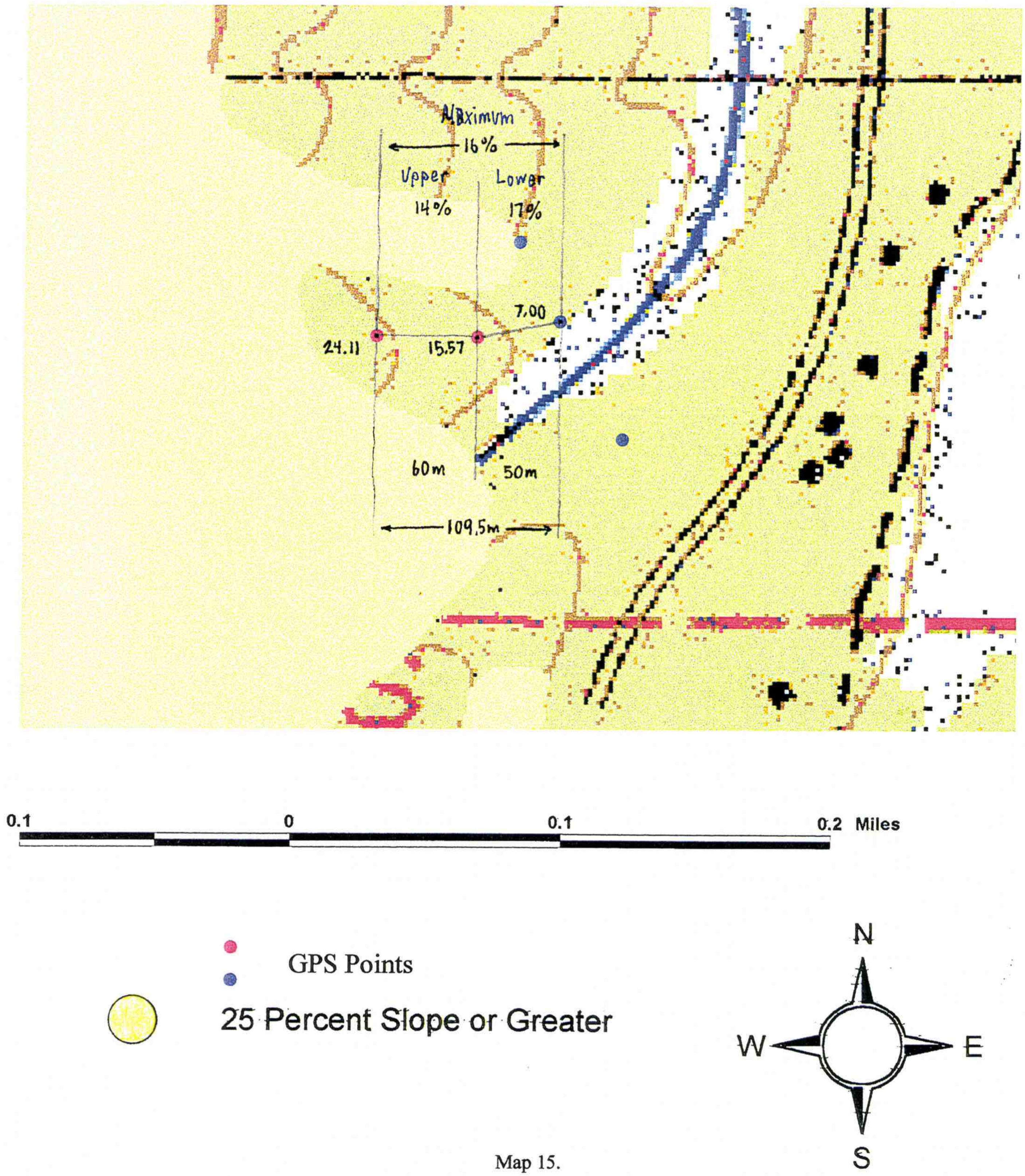
Site 1-Map 15

Site One consists of three points. The maximum transect slope is 16 percent, while the intermediate slopes are 17 percent for the lower portion and 14 percent for the upper. While ascending the slope, it was noted that the trail from which the points were collected lay higher than the land to the north and south which appeared to have a steeper slope as it dropped away. There was no visible slope hazard.

Site 2-Map 16

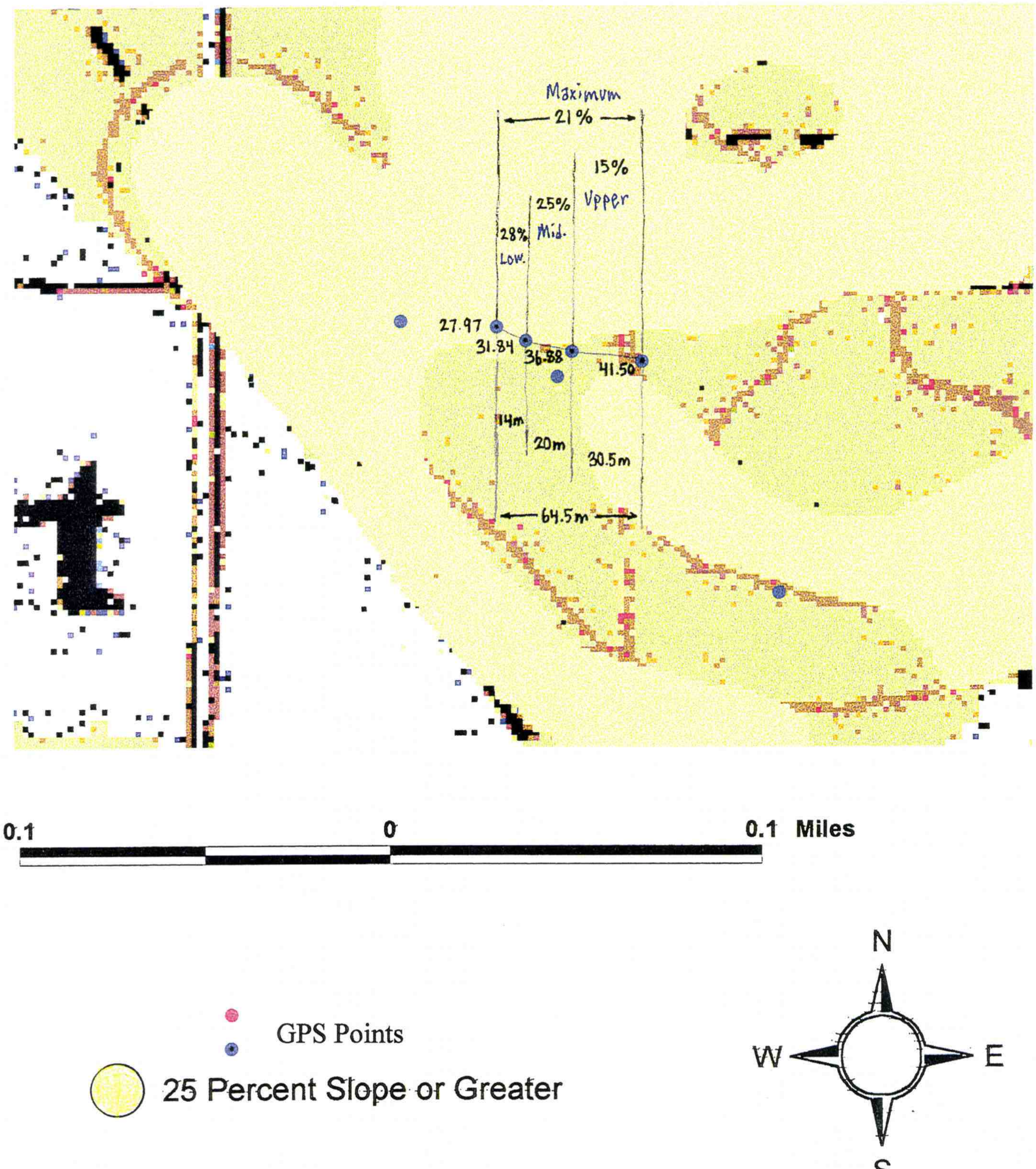
Four GPS points were utilized in the slope calculation. The maximum transect slope was 21 percent, the lower section is 28 percent, the middle section has a 25 percent slope, and the upper section is 15 percent. The points were collected in a clearing approximately 50 meters wide, trending upslope, and bisected by a logging road 3/4 of the way up. The middle section appeared steep but with no visible slope failure.

GPS Survey Site #1-Reedsport



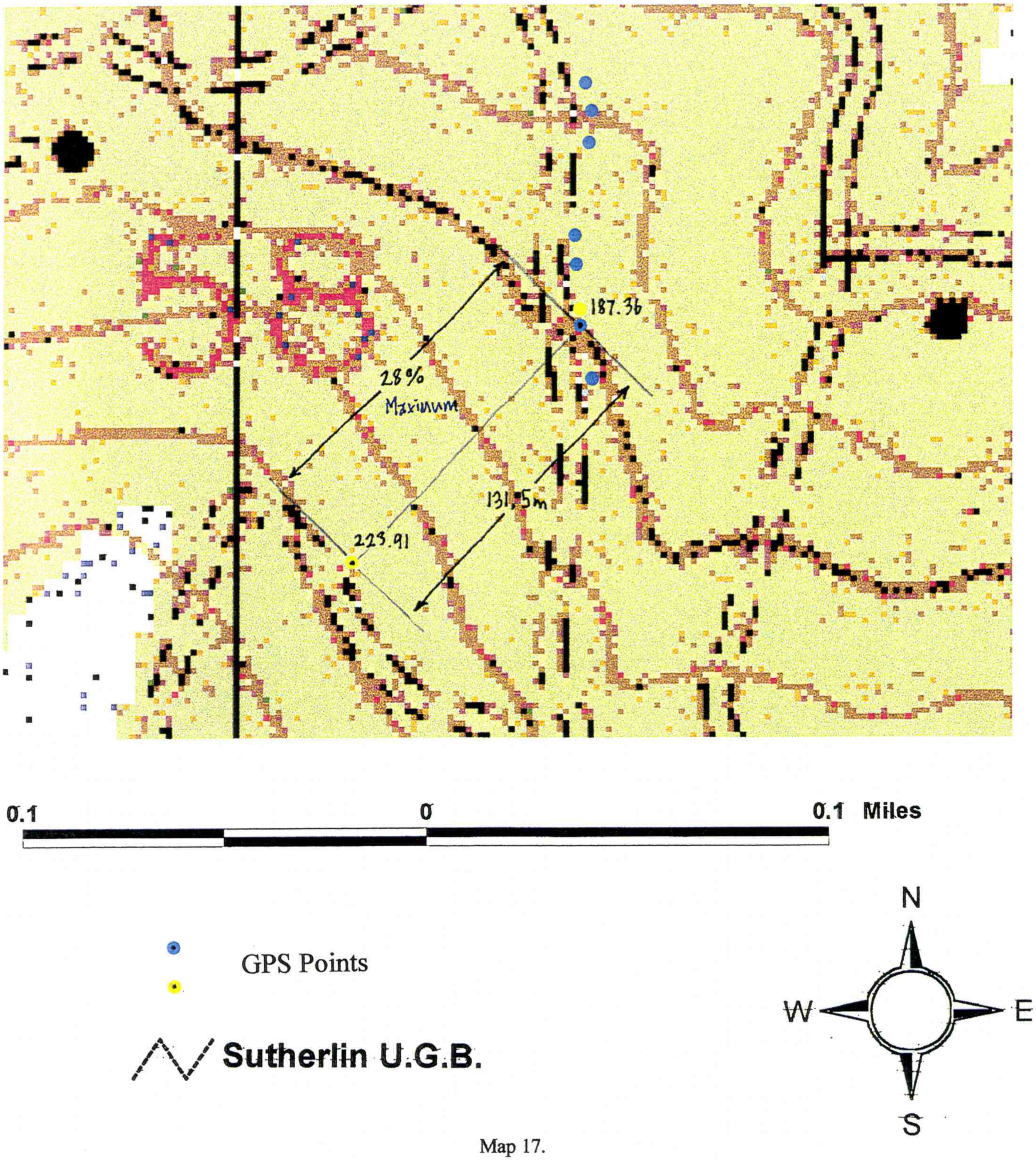
Map 15.

GPS Survey Site #2-Reedsport



Map 16.

GPS Survey Site #3-Sutherlin



Map 17.

Site 3-Map 17

Site 3 consists of two usable points. The slope between them is 28 percent. The GPS survey was conducted along a road which climbs to a ridge with several residential structures. The two points mark the top and bottom of an area of slope failure between a switch back in the road. The top of the slumping landform began just above the road recently removing a section approximately 60 meters wide . The bottom of this feature mounded over the road with debris found approximately 30 meters below. It is apparent that public works crews recently cleared the debris below and fixed the road above, but did not attempt to solve the problem. At the foot of the slump land has mounded approximately 30 meters high with a flat top and many fallen and leaning trees. The possibility of future slope failure still exists at this site.

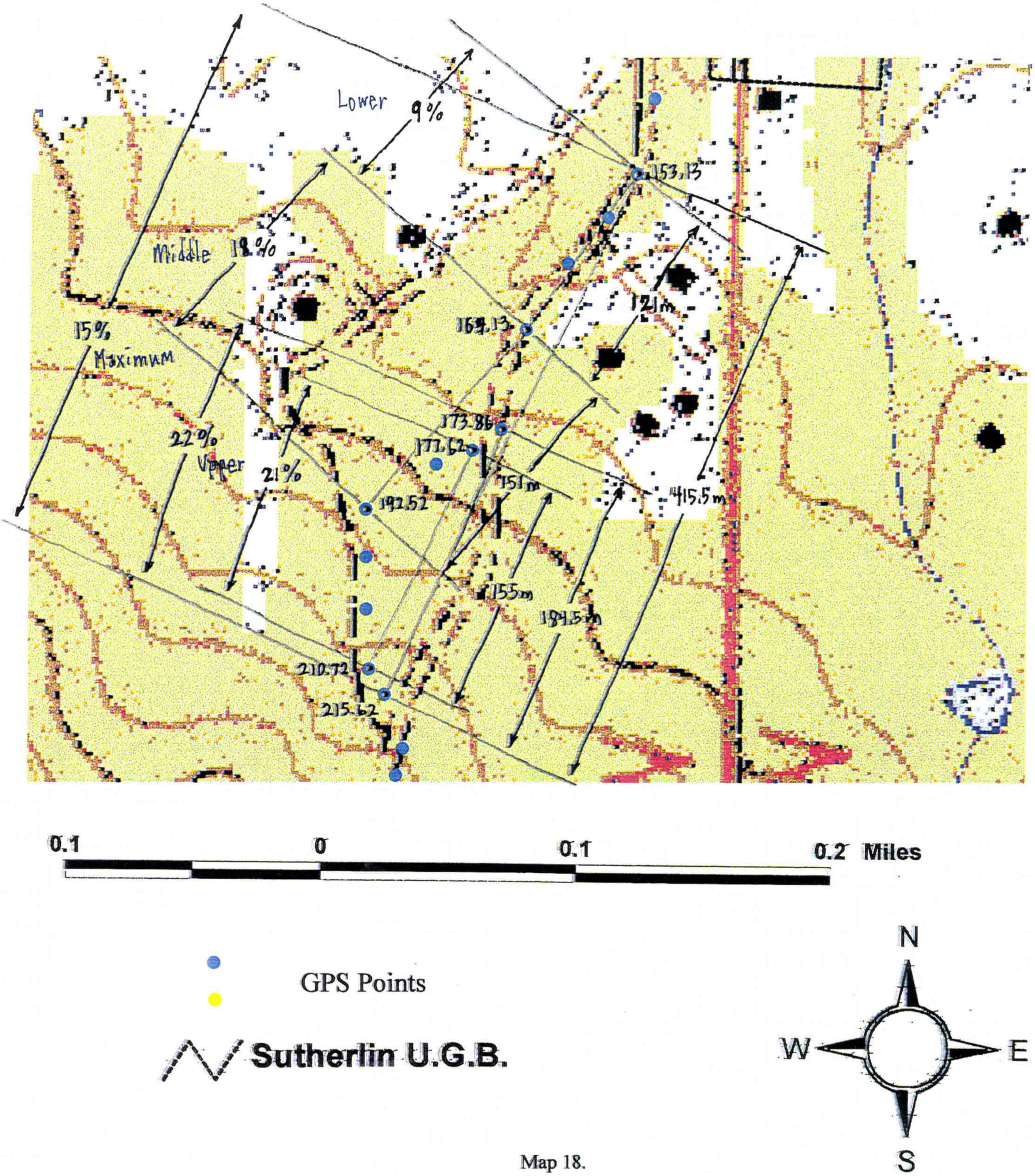
Site 4-Map 18

Site 4 provides seven data points. Five transects, consisting of the maximum, two upper section, and one middle and one lower section transects, were used to calculate a variety of percent slope values. The two parallel upper sections, with 21 and 22 percent slopes, are the steepest. The middle section is 18 percent, and the lower section is 9 percent. The maximum transect has a 15 percent slope. Along the paved road used for the survey, there were no visible slope hazards.

Site 5-Map 19

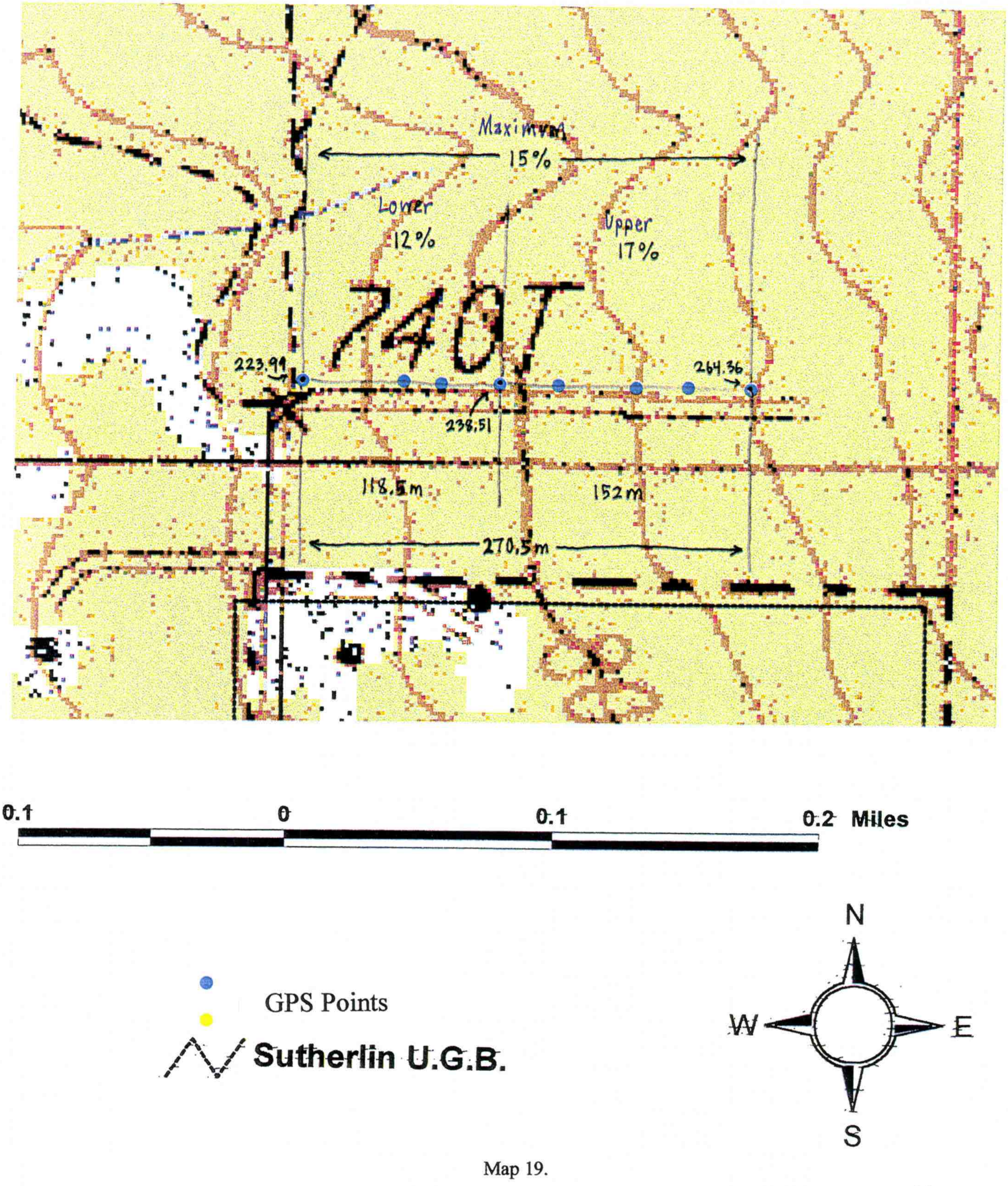
Site 5 consists of three GPS points collected along a residential road. The maximum transect slope is 15 percent. The upper section has a 17 percent slope, while, the lower section has a 12 percent slope. There were no apparent slope hazards.

GPS Survey Site #4-Sutherlin



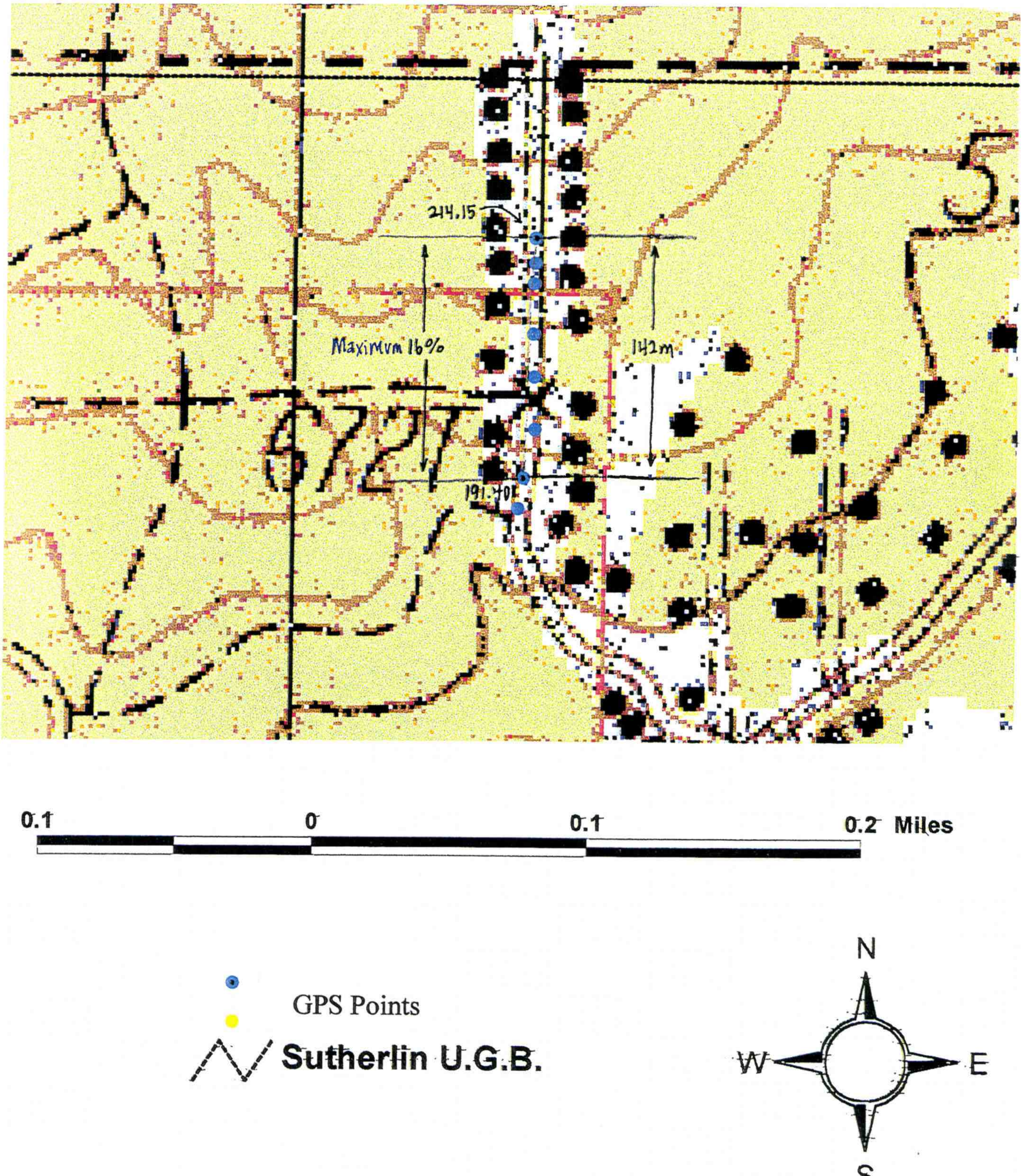
Map 18.

GPS Suvey Site #5-Sutherlin



Map 19.

GPS Survey Site #6-Sutherlin



Map 20.

Site 6-Map 20

Site 6 was also surveyed along a residential road trending directly upslope. Two data points were utilized in determing the 16 percent slope of the maximum transect. No slope hazards were visible.

The slope analysis from the GPS survey provides data at multiple scales to support the effectiveness of the manual contour analysis. Every site analysis with three or more GPS points was broken into multiple scales, ie. the maximum transect and each section. Since each section had different percent slope values, it is obvious that the closer the data points the finer the resolution, providing the greatest detail. As expected, when visually comparing the GPS percent slope values with the contour spacing, the percent slope values consistently increase as gap size decreases. The best examples of this are found in Study Sites 2 and 4.

Study Site 2 is unique in that it is the only survey site where data points are inside and outside the area delineated from the contour analysis as unbuildable-25 percent or greater. The lower transect, completely inside the Unbuildable Zone, has a GPS slope value of 28 percent. The middle transect, which crosses the zone boundary, has a GPS slope value of 25 percent. The upper section, completely in the Buildable Zone, has a GPS slope value of 15 percent. This necessary detail is not present at the scale of the maximum transect, which has a GPS slope value of 21 percent.

In Study Site 4, the contours narrow with increased elevation. The lowest contour gap is approximately 1/5 inch, mathematically corresponding to 10 percent slope. The highest contour gap is slightly narrower than 1/10 inch, corresponding to 20 percent slope. In general, when comparing the manual contour analysis range of 10 to just over 20 percent slope, to the GPS analysis range of 9-22 percent slope, the contour analysis appears to be relatively accurate.

Discussion

To determine the limitations of the percent slope maps created, several aspects of the analysis are discussed. Also discussed is the utility of the map and the study in general. Finally, the possibilities of improving the map and the mapping process are discussed.

Reclassification of Soils Polygons

It is not surprising that the reclassification of the soils data did not produce any new information. The main reason for this is that the soils data layer is exactly that, soils data. The range of values for percent slope is just that, a range of values. The use of these data to map percent slope is inappropriate at the local scale. The polygons were delineated from aerial photography at 1:20000 scale and sampled at a few points within the polygon at best. The scale and sampling method was aimed at defining soils class. The polygons only define one spatial variable-soils. That is why most soils classes do not have a single slope value.

Alternative Slope Determination

The use of the 1:24000 scale, 7.5 Minute USGS Topographic Map contours provides a percent slope map spatially consistent with that scale. The accuracy of the percent slope map is obviously dependent upon the quality of the aerial photography used in producing the contour map, the care and skill of the people creating the topographic map, and the care and skill of the people performing the percent slope contour analysis.

GPS Slope Survey

The GPS slope survey provided some quality data but is still subject to limitations. In the field, problems such as steep slopes, forest cover, and private property rights can limit the areas which can be surveyed. The lengths of the transects were relative short. Longer transects and several close together might provide greater insight into the accuracy of the percent slope data.

The visual, slope hazard survey demonstrated the need for accurately mapping those areas defined as unbuildable. Of the two areas found to have 25 percent slope or greater, one was developed, i.e. a paved road with daily use, and that one had slope failure in the form of slumping. The lower section transect of Site 2 has a 28 percent slope, is covered in low vegetation, is not cut by a road, and does not appear to have any slope failure or hazards. Study Site 3 has a 28 percent slope, is covered by timber with a sparse understory, is cut twice by an often used road, and is experiencing failure. Failure is probably occuring from shaking of the ground by vehicles, changes in surface flow patterns, and excessive saturation. All sites with less than 25 percent slopes had no apparent slope hazards.

Map Utility

The percent slope map created is intended to be used in the proccess of determining Buildable Lands. The map identifies buildable and unbuildable slope. This map should be included in the Buildable Lands Inventory for Reedsport. Compared with other layers in the GIS project like the 100-year flood zone, Soil characteristics, Economic feasibility, and environmentally protected areas an accurate map of potentially Buildable Lands may be produced. The identification of Buildable Lands is not intended, nor should it be, to replace site level determination. For every given parcel of land, before development takes place, site surveys should be conducted to determine the best possible location for that development.

Map Improvement

Several steps could be taken to provide more accurate percent slope maps. For many larger communities larger scale contour maps and 10-meter DEM's exist. Both data sources would provide higher resolution maps. Each community that utilizes available data sources should conduct site level surveys either with GPS or manual survey methods to check the accuracy of the smaller scale data being used.

Conclusion

Accurately determining buildable slope and ultimately Buildable Lands is an important part of proper land use planning. For many smaller, generally poorer communities faced with identifying such slopes, the percent slope contour analysis performed in this project is an appropriate method. The use of data that have slope as a secondary feature, i.e. soils data, is not acceptable for determining buildable slope at an appropriate scale. Proper identification of buildable slope can potentially help avoid slope failure caused by human landscape alteration and prevent loss of property and life.

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Oregon's Department of Land Conservation and Development (DLCD)

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A Summary of Oregon's Statewide Planning Goals

A link to the full-text of the Statewide Planning Goals is available courtesy of the University of Oregon.

Oregon's Land Use Program includes nineteen statewide planning goals. Cities and counties must adopt comprehensive plans and ordinances which are consistent with these goals. Following is a summary of the statewide planning goals. More detailed information on the goals is available under Statwide Planning Goals.

1. *Citizen Involvement* -- Goal 1 calls for "the opportunity for citizens to be involved in all phases of the planning process." It requires each city and county to have a citizen involvement program with six components specified in the goal. It also requires local governments to have a committee for citizen involvement (CCI) to monitor and encourage public participation in planning.

2. *Land Use Planning* --Goal 2 outlines the basic procedures of Oregon's statewide planning program. It says that land-use decisions are to be made in accordance with a comprehensive plan, and that suitable "implementation ordinances" to put the plan's policies into effect must be adopted. It requires that plans be based on "factual information"; that local plans and ordinances be coordinated with those of other jurisdictions and agencies; and that plans be reviewed periodically and amended as needed.

   Goal 2 also contains standards for taking exceptions to statewide goals. An exception may be taken when a statewide goal cannot or should not be applied to a particular area or situation.

3. *Agricultural Lands* -- Goal 3 defines "agricultural lands." It then requires counties to inventory such lands and to "preserve and maintain" them through exclusive farm use (EFU) zoning (per ORS Chapter 215).

4. *Forest Lands* -- This goal defines forest lands and requires counties to inventory them and adopt policies and ordinances that will "conserve forest lands for forest uses."

5. *Open Spaces, Scenic and Historic Areas, and Natural Resources* -- Goal 5 encompasses 12 different types of resources, including wildlife habitats, mineral resources, wetlands and waterways. It establishes a process through which resources must be inventoried and evaluated. If a resource or site is found to be important, the local government has three policy choices: to preserve the resource, to allow the proposed uses that conflict with it, or to establish some sort of a balance between the resource and those uses that would conflict with it.

6. *Air, Water and Land Resources Quality* --This goal requires local comprehensive plans and implementing measures to be consistent with state and federal regulations on matters such as groundwater pollution.

7. *Areas Subject to Natural Disasters and Hazards* -- Goal 7 deals with development in places subject to natural hazards such as floods or landslides. It requires that jurisdictions apply "appropriate safeguards" (floodplain zoning, for example) when planning for development there.

8. *Recreation Needs* -- This goal calls for each community to evaluate its areas and facilities for recreation and develop plans to deal with the projected demand for them. It also sets forth detailed standards for expedited siting of destination resorts.

9. *Economy of the State* -- Goal 9 calls for diversification and improvement of the economy. It asks communities to inventory commercial and industrial lands, project future needs for such lands, and plan and zone enough land to meet those needs.

10. *Housing* -- This goal specifies that each city must plan for and accommodate needed housing types (typcially, multifamily and manufactured housing). It requires each city to inventory its buildable residential lands, project future needs for such lands, and plan and zone enough buildable land to meet those needs. It also prohibits local plans from discriminating against needed housing types.

11. *Public Facilities and Services* -- Goal 11 calls for efficient planning of public services such as sewers, water, law enforcement, and fire protection. The goal's central concept is that public services should to be planned in accordance with a community's needs and capacities rather than be forced to respond to development as it occurs.

12. *Transportation* -- The goal aims to provide "a safe, convenient and economic transporta- tion system." It asks for communities to address the needs of the "transportation disadvantaged."

13. *Energy* -- Goal 13 declares that "land and uses developed on the land shall be managed and controlled so as to maximize the conservation of all forms of energy, based upon sound economic principles."

14. *Urbanization* -- This goal requires all cities to estimate future growth and needs for land and then plan and zone enough land to meet those needs. It calls for each city to establish an "urban growth boundary" (UGB) to "identify and separate urbanizable land from rural land." It specifies seven factors that must be considered in drawing up a UGB. It also lists four criteria to be applied when undeveloped land within a UGB is to be converted to urban uses.

15. *Willamette Greenway* -- Goal 15 sets forth procedures for administering the 300 miles of greenway that protects the Willamette River.

16. *Estuarine Resources* -- This goal requires local governments to classify Oregon's 22 major estuaries in four categories: natural, conservation, shallow-draft development, and deep-draft development. It then describes types of land uses and activities that are permissible in those "management units."

17. *Coastal Shorelands* -- The goal defines a planning area bounded by the ocean beaches on the west and the coast highway (State Route 101) on the east. It specifies how certain types of land and resources there are to be managed: major marshes, for example, are to be protected. Sites best suited for unique coastal land uses (port facilities, for example) are reserved for "water-dependent" or "water-related" uses.

18. *Beaches and Dunes* -- Goal 18 sets planning standards for development on various types of dunes. It prohibits residential development on beaches and active foredunes, but allows other types of development if they meet key criteria. The goal also deals with dune grading, groundwater drawdown in dunal aquifers, and the breaching of foredunes.

19. *Ocean Resources* -- Goal 19 aims "to conserve the long-term values, benefits, and natural resources of the nearshore ocean and the continental shelf." It deals with matters such as dumping of dredge spoils and discharging of waste products into the open sea. Goal 19's main requirments are for state agencies rather than cities and counties.

Updated: 11/97

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Appendix B

EXHIBIT A 3/26/99

CITIES SUBJECT TO REQUIREMENTS OF ORS 197.296

(Excluding cities for which a waiver was granted by LCDC)

City	1998 Population Estimates	Periodic Review Notice Date	Reason
Albany	38,925	Sept. 1997	Population over 25,000 & Growth Rate
Ashland	19,220	N/A	Growth Rate
Aumsville	2,875	Jan 1995	Growth Rate
Beaverton	68,050	N/A	Metro, Growth Rate & Population over 25,000
Bend	35,635	Nov. 1998	Growth Rate & Population over 25,000
Boardman	2,795	Nov. 1997	Growth Rate
Brookings	5,510	N/A	Growth Rate
Canby	12,465	July 1998	Growth Rate
Canyonville	1,340	July 1997	Growth Rate
Central Point	11,255	N/A	Growth Rate
Columbia City	1,635	N/A	Growth Rate
Cornelius	8,170	Sept. 1996	Metro
Corvallis	49,630	May 1996	Growth Rate & Population over 25,000
Cottage Grove	8,190	N/A	Growth Rate
Creswell	3,150	N/A	Growth Rate
Culver	850	N/A	Growth Rate
Dallas	12,530	Jan 1995	Growth Rate
Dayton	1,920	N/A	Growth Rate
Donald	700	May 1996	Growth Rate
Dundee	2,735	May 1996	Growth Rate
Durham	1,555	N/A	Metro & Growth Rate
Eagle Point	4,325	N/A	Growth Rate
Echo	640	Nov. 1998	Growth Rate
Eugene	133,460	Sept 1993	Growth Rate & Population over 25,000
Fairview	5,910	N/A	Metro & Growth Rate
Florence	6,715	N/A	Growth Rate
Forest Grove	16,170	March 1997	Metro & Growth Rate

Exhibit A, Continued
Cities Subject to ORS 197.296, 1999

City	1998 Population Estimates	Periodic Review Notice Date	Reason
Gervais	1,370	Jan. 1995	Growth Rate
Gladstone	11,745	Sept. 1996	Metro
Gresham	83,595	Jan. 1996	Metro, Growth Rate & Population over 25,000
Happy Valley	3,540	N/A	Metro & Growth Rate
Harrisburg	2,535	Sept. 1996	Growth Rate
Hermiston	11,595	N/A	Growth Rate
Hillsboro	65,110	N/A	Metro, Growth Rate & Population over 25,000
Independence	5,815	July 1997	Growth Rate
Irrigon	1,330	N/A	Growth Rate
Jefferson	2,335	N/A	Growth Rate
Johnson City	625	Nov. 1997	Metro
Junction City	4,400	N/A	Growth Rate
Keizer	29,235	N/A	Growth Rate & Population over 25,000
King City	2,125	N/A	Metro
Lafayette	2,140	N/A	Growth Rate
Lake Oswego	34,280	N/A	Metro & Population over 25,000
Lebanon	12,480	April 1993	Growth Rate
Lincoln City	6,855	N/A	Growth Rate
Madras	5,005	Jan. 1996	Growth Rate
Maywood Park	795	Nov. 1997	Metro
McMinnville	24,265	Aug. 1988	Growth Rate
Medford	58,895	N/A	Population over 25,000 & Growth Rate
Milton-Freewater	6,500	N/A	Growth Rate
Milwaukie	20,220	N/A	Metro
Molalla	5,395	March 1997	Growth Rate
Monmouth	7,980	July 1997	Growth Rate
Myrtle Creek	3,600	N/A	Growth Rate
Newberg	17,355	N/A	Growth Rate
Newport	10,240	N/A	Growth Rate
North Plains	1,760	Jan. 1996	Growth Rate

Exhibit A, Continued
Cities Subject to ORS 197.296, 1999

City	1998 Population Estimates	Periodic Review Notice Date	Reason
Ontario	10,680	N/A	Growth Rate
Oregon City	22,560	N/A	Metro & Growth Rate
Philomath	3,770	May 1996	Growth Rate
Phoenix	3,905	N/A	Growth Rate
Portland	509,610	N/A	Metro & Population over 25,000
Prineville	6,920	N/A	Growth Rate
Redmond	12,435	N/A	Growth Rate
Rivergrove	300	N/A	Metro
Roseburg	20,215	N/A	Growth Rate
St. Helens	9,060	Jan. 1996	Growth Rate
Salem	126,635	Jan. 1988	Growth Rate & Population over 25,000
Sandy	5,135	N/A	Growth Rate
Scappoose	4,855	Jan. 1996	Growth Rate
Seaside	6,170	N/A	Growth Rate
Shady Cove	2,315	Jan. 1996	Growth Rate
Sheridan	5,330	N/A	Growth Rate
Sherwood	9,600	N/A	Metro & Growth Rate
Silverton	6,740	July 1997	Growth Rate
Springfield	51,700	Sept. 1993	Population over 25,000 and Growth Rate
Stanfield	1,820	Nov. 1998	Growth Rate
Stayton	6,655	March 1999	Growth Rate
Sublimity	2,400	May 1996	Growth Rate
Sutherlin	6,690	N/A	Growth Rate
Sweet Home	7,815	March 1996	Growth Rate
Talent	5,050	N/A	Growth Rate
Tangent	1,045	May 1996	Growth Rate
Tigard	37,200	N/A	Metro, Growth Rate & Population over 25,000
Toledo	3,590	N/A	Growth Rate
Troutdale	14,040	N/A	Metro & Growth Rate
Tualatin	21,405	N/A	Metro & Growth Rate

Exhibit A, Continued
Cities Subject to ORS 197.296, 1999

City	1998 Population Estimates	Periodic Review Notice Date	Reason
Umatilla	3,515	N/A	Growth Rate
Veneta	2,950	May 1996	Growth Rate
Warrenton	4,175	N/A	Growth Rate
West Linn	21,405	N/A	Metro & Growth Rate
Wilsonville	12,290	Jan. 1996	Metro & Growth Rate
Winston	4,480	Jan. 1996	Growth Rate
Wood Village	3,005	Sept. 1996	Metro
Woodburn	16,585	May 1996	Growth Rate

N/A = Not currently scheduled for periodic review notice in 1999.
Growth rate = Exceeded state average for three of the last five years.

March 31, 1999
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